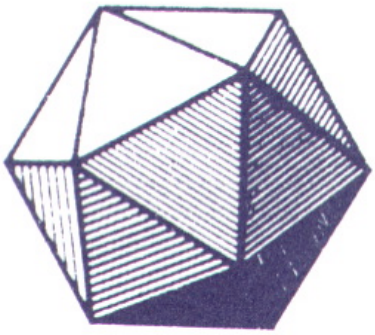
North Central Section (Founded in 1916)

Mathematical Association of America



Spring Meeting • April 20-21, 2018
Minnesota State University, Mankato
Mankato, Minnesota

Friday, April 20, 2018

6:30 – 8:10 **Registration** – Armstrong Hall #123
$15 (Free for Students and Invited Speakers)

6:30 – 8:00 **Book Sales**, Armstrong Hall #205
Internet access: Wireless access is available

Evening Session – Armstrong Hall #101, Namyong Lee, Presiding

7:20 – 7:40 **Bryan Freyberg, Southwest Minnesota State University**
Regular d-handicap Graphs of Even Order

7:45 – 8:10 **Shawn Chiappetta (University of Sioux Falls), Co Livingston (Bemidji State University), Heather Moreland (Southwest Minnesota State University), John Zobitz (Augsburg University)**
Panel Discussion: Applied Mathematics in the Small College

8:15 – 9:00 **Cindy Kaus, Metropolitan State University**
(Winner of 2017 NCS Teaching Award)
Transforming the Mathematics Classroom to Truly Embrace Diversity

9:00 – 10:00 **Welcome Reception** – Students Union #245

Saturday, April 21, 2018

8:30 – 11:00 **Registration** – Armstrong Hall #123
8:30 – 11:00, 12:00-2:00 **Book Sales** – Armstrong Hall #205

9:00 – 9:05 **Welcome,** Armstrong Hall #101
Dean, Brian Martensen (College of Science, Engineering & Technology)

Section NExT Invited Speaker – Armstrong Hall #101, Ruijun Zhao, Presiding
9:05 – 9:50 **Brandon Rowekamp, Minnesota State University, Mankato**
Discrete Flows on Simplicial Complexes

Morning Concurrent Session I – Armstrong Hall #101, Ruijun Zhao, Presiding

10:00 –10:20 **Joel Iiams, University of North Dakota**
From Gauss to Gauss

10:25 – 10:45 **Ke Zhu, Minnesota State University, Mankato**
Solvability of Dirac Type Equations and Automatic Transversality of Holomorphic Curves

Morning Concurrent Session II – Armstrong Hall #102, Dan Singer, Presiding

10:00 – 10:20 **Matthew Zabka, Southwest Minnesota State University**
Random Operators in Algebraic Topology

10:25 –10:45 **Bruce Dearden, University of North Dakota**
Apparent Random Behavior in Running Modulus Recursions

Morning Concurrent Session III – Armstrong Hall #208, Donna Flint

10:00 – 10:50 **Section NExT Workshop**
Donna Flint, South Dakota State University
Teaching and Acting

Invited Lecture – Armstrong Hall #101, Ruijun Zhao, Presiding
11:00 – 11:50 **Peter J. Olver, University of Minnesota, Twin Cities**
Reassembly of Broken Objects

12:00 – 1:00 **Luncheon** – Students Union #245

1:15 – 1:45 **Business Meeting** – Armstrong Hall #101, Namyong Lee, Section President Presiding

Afternoon Concurrent Session I Armstrong Hall #101, Hyekyung Min, Presiding

2:00 – 2:20 **Dan Singer, Minnesota State University, Mankato**
Teaching Introduction to Mathematical Software Programming at Minnesota State University, Mankato

2:25 – 2:45 **Joe Benson, Macalester College**
Success, Failures, and Reflections on IBL Approaches

2:45 – 2:55 **Break –** Armstrong Hall #123

2:55 – 3:15 **Melissa Lynn, University of Minnesota, Twin Cities**
Sums-of-Squares Formulas over Arbitrary Fields

3:20 – 3:40 **Noureddine Benchama, Minnesota State Community College, Moorhead**
Non-calculus Activity and Proof about the Maximum Number of Extrema of a Polynomial

Afternoon Concurrent Session II – Armstrong Hall #102, Ke Zhu, Presiding

2:00 – 2:20 **Willam Schwalm (University of North Dakota, Physics and Astrophysics), Christian Peterson (University of North Dakota, Undergraduate, Physics and Electrical Engineering)**
Euler's Rotation Equation for a Freely Rotating Object and Dzhanibekov Effect

2:25 – 2:45 **Doug Anderson, Concordia College, Moorhead**
Hyers-Ulam Stability of First-order Linear Equations on Time Scales

2:45 – 2:55 **Break –** Armstrong Hall #123

2:55 – 3:15 **Brad Lowery, University of Sioux Falls**
A Tight Communications Lower Bound for Matrix-Matrix Multiplication

3:20 – 3:40 **Jung-Han Kimn, South Dakota State University**
Numerical Study on Homogeneous and Inhomogeneous Dirac Equations Using Discretization Based on Light Cone Coordinates

Local Organizing Committee:
Ke Zhu (Chair), Soo Yeon Shin, Ruijun Zhao, Han Wu, Hyekyung Min, Kyung Il Lee, Wook Kim, Iresha Premarathna, Sarah Lanand

Abstracts

Invited Addresses

- **Cindy Kaus,** Metropolitan State University, **Transforming the Mathematics Classroom to Truly Embrace Diversity**

Mathematics students from diverse backgrounds have the power to serve as invaluable resources for their classmates, teachers and the community. They bring a broad range of experiences and perspectives that enrich the learning environment. How do we transform the classroom to support and encourage students from all backgrounds to adopt the identity of a mathematical thinker? What structural barriers are in place that we must move beyond? How do we change our students' mathematical stories so that they learn to appreciate the beauty and applications of mathematics and also have confidence in their mathematical ability? I will present a model that addresses these questions for a group of students who have taken me on a professional path I never expected.

- **Peter J. Olver,** University of Minnesota, Twin Cities, **Reassembly of Broken Objects**

The problem of reassembling broken objects appears in a broad range of applications, including jigsaw puzzle assembly, archaeology (broken pots and statues), surgery (broken bones and reassembly of histological sections), paleontology (broken fossils and egg shells), and anthropology (more broken bones). I will discuss recent progress on such problems, based on advances in the mathematical apparatus of transformation groups and groupoids, symmetry and equivalence problems, moving frames, invariant signatures, and invariant numerical approximations.

Section NExT Invited Speaker

- **Brandon Rowekamp,** Minnesota State University, Mankato, **Discrete Flows on Simplicial Complexes**

Morse theory and related fields show that many topological properties of manifolds can be understood through analyzing possible vector fields on them, or equivalently by analyzing flows. Discrete Morse theory, which has found applications in many different fields throughout the last decade, does the same sort of analysis starting from a CW complex. Using the framework developed by discrete Morse theory we can discuss notions of vector fields and flows on a simplicial complex in simple and purely combinatorial terms. This framework allows us to attack problems by either using intuitions from our experience with vector fields and flows in the smooth case, or by applying results and techniques from graph theory to the combinatorial interpretation. In this talk we will develop the notion of combinatorial flows from the ground up, and examine some related problems which illustrate how they connect topology to graph theory.

Section NExT Workshop

- **Donna Flint,** South Dakota State University, **Teaching and Acting**

We all agree that a critical part of teaching mathematics or any other topic is engaging students. Though we often focus on creating materials, asking good questions, and finding "real-life" applications which will engage students, we cannot minimize the basic value of the **faculty presence** in the room. In this workshop, we'll draw on the expert advice of actors and acting coaches to help us explore skills that will help us be a more engaging presence in the classroom.

Contributed Talks

- **Doug Anderson,** Concordia College, Moorhead, **Hyers-Ulam Stability of First-order Linear Equations on Time Scales**

We explain what Hyers-Ulam stability (HUS) is for differential equations, and then explore some examples of HUS for first-order linear equations for different time scales.

- **Noureddine Benchama,** Minnesota State Community College, Moorhead, **Non-calculus Activity and Proof about the Maximum Number of Extreme of a Polynomial**

We show via graphing how insight into the behavior of a polynomial graph between successive zeros determine the existence of extrema, then use induction to prove that a polynomial with degree n must have at most $(n-1)$ extrema.

- **Joe Benson,** Macalester College**, Success, Failures, and Reflections on IBL Approaches**

In recent years, studies have shown active learning strategies to be more effective in creating a successful culture of learning in the mathematics classroom. Inquiry Based Learning (IBL) falls under the active learning umbrella, generally featuring a carefully designed sequence of questions that students answer in order to discover truths about the course content. I taken an inquiry-based approach to several classes in the past few years, and this talk aims to report on some of struggles, successes, and thoughts. In addition, I hope to reach out to others who want to or are currently implementing IBL in their classrooms.

- **Shawn Chiappetta** (University of Sioux Falls)**, Co Livingston** (Bemidji State University), **Heather Moreland** (Southwest Minnesota State University), **John Zobitz** (Augsburg University)**, Panel Discussion: Applied Mathematics in the Small College**

The members of this panel will discuss strategies for preparing students in applied mathematics at schools with small math programs. Questions and advice from the audience are desired.

- **Bruce Dearden,** University of North Dakota, **Apparent Random Behavior in Running Modulus Recursions**

A running modulus recurrence (rumor) is a recurrence relation where z_0, the initial seed, is any positive integer and successive terms are given by the formula $z_n = b * z_{n-1} + c \ (mod\ n)$, where $b \geq 2$. We will discuss empirical evidence for universal behaviors of a rumor sequence and hypotheses for those behaviors. In particular, we will that the rumor model satisfies conditions, due to Lagarias, that places the rumor system among dynamical systems that apparently produce random digits in the form of normal numbers. Consequences of this normality hypothesis are considered, with confirming empirical evidence.

- **Bryan Freyberg,** Southwest Minnesota State University, **Regular d-handicap Graphs of Even Order**

Let $G = (V, E)$ be a simple, undirected graph of order n. Let ℓ be a bijection from V to the natural numbers, and for all $i \in \{1,2,\ldots,n\}$, define the weight of the vertex x_i as $w(x_i) = \sum_{x_I x_j \in E} \ell(x_j)$. If ℓ has the property that $\ell(x_i) = i$ and the sequence of weights $w(x_1), w(x_2), \ldots, w(x_n)$ is d-arithmetic for some $d > 1$, then we say that G is a d-handicap graph. The motivation for studying these graphs stems from tournament design. A k-regular, d-handicap graph on n vertices corresponds to a tournament on n teams, each ranked according to strength with the natural numbers, in which each team plays exactly k opponents, and the strength of schedule (the sum of opponent rankings) increases d-arithmetically with strength of team. In this talk, we provide necessary and sufficient conditions for the existence of regular d-handicap graphs for all orders $n \equiv 0\ mod\ (2^{d+2})$.

- **Joel Iiams,** University of North Dakota, **From Gauss to Gauss**

We start with a topic in number theory studied in depth by Gauss. We follow the mathematical translations of a special example, dropping names along the way, finishing with another theme of inquiry in number theory studied in depth by Gauss. The story cuts a fairly wide swath through mathematics including designs, geometries, codes, weighing schemes, and algebraic number theory. As a disclaimer: the path is not in historical order, and at least part of the storyline is anecdotal.

- **Jung-Han Kimn,** South Dakota State University, **Numerical Study on Homogeneous and Inhomogenous Dirac Equations Using Discretization Based on Light Cone Coordinates**

In this work, we propose that simulation behavior is directly affected by choice of discretization method. We present our current numerical results for the homogeneous and inhomogeneous Dirac equation based on coordinate rotation. This method is motivated by the characteristic nature of relativistic system which is commonly known as a light cone. The preliminary results show that the optimal angle based on condition number analysis is 45 angle which is the angle of light rays in spacetime. To investigate more general cases, we have implemented parallel codes based PETSc for the large scale cases. Work done jointly with Jonathan Hedman (South Dakota State University, undergraduate), Brad Lowery (University of Sioux Falls), and Nicholas Stegmeier (South Dakota State University, graduate).

- **Brad Lowery,** University of Sioux Falls, **A Tight Communications Lower Bound for Matrix-Matrix Multiplication**

A tight lower bound for required communications when computing a matrix-matrix multiplication on a processor with two layers of memory is established. Previous work established lower bounds such that the best-known algorithms were only asymptotically optimal. We improve the lower bound and present a theoretical algorithm that obtains the lower bound. The new lower bound is $2mnk\sqrt{S} - 2S$, where S is the size of fast memory and m, n, and k depend on the size of the matrices.

- **Melissa Lynn,** University of Minnesota, Twin Cities, **Sums-of-Squares Formulas over Arbitrary Fields**

Determining the existence of sums-of-squares formulas is a classical problem, dating back to Hurwitz's proof that the only real normed division algebras are the real numbers, the complex numbers, the quaternions, and octonions. Sums-of-squares formulas over arbitrary fields generalize real normed division algebras, and they have been studied using linear algebra, number theory, topology, geometry, combinatorics, and modern algebraic methods. This talk will discuss the history of the problem and introduce a new approach using algebraic geometry.

- **William Schwalm** (University of North Dakota, Physics and Astrophysics), **Christian Peterson** (University of North Dakota, undergraduate, Physics and EE), **Euler's Rotation Equation for a Freely Rotating Object and Dzhanibekov Effect**

Euler's rotation equations, a set of non-linear coupled ODE's, are solved analytically in the non-inertial or body frame of reference in terms of Jacobi's Elliptic functions. The solution constructs a transformation between the stationary and rotating frames by giving the time dependence of the Euler angles, ϕ, θ, and ψ that define three factors of the rotation matrix. A computer animation of the elliptic function solution is applied to explain the flipping motion of a spinning T-handle in zero gravity, known as the Dzhanibekov effect, seen in several famous videos on the internet. Video of the Dzhanibekov effect at:
https://www.youtube.com/watch?v=1n-HMSCDYtM

- **Dan Singer,** Minnesota State University, Mankato, **Teaching Introduction to Mathematical Software Programming at Minnesota State University, Mankato**

I am teaching this class for the first time in Spring 2018. Its purpose is to introduce math majors to symbolic computation and programming techniques using a technical computing system such as Mathematica. I will describe my approach to teaching this course, the class demonstrations I have prepared, the projects I have designed, and discuss what has and hasn't worked this semester.

- **Matthew Zabka,** Southwest Minnesota State University, **Random Operators in Algebraic Topology**

A relatively new application of topology involves using homology to analyze large data sets. This raises the question as to whether it is possible to use other topological invariants in data analysis. This presentation will contain some recent results on cohomology operators on random spaces, as well as random operators in a strictly algebraic setting.

- **Ke Zhu,** Minnesota State University, Mankato, **Solvability of Dirac Type Equations and Automatic Transversality of Holomorphic Curves**

We develop a weighted L^2-method for the (half)-Dirac equation. For Dirac bundles over Riemann surfaces, we give a sufficient condition for the solvability of the Dirac equation in terms of a curvature integral. Applying this to the Dolbeault-Dirac operator, we establish an automatic transversality criteria for holomorphic curves in Kahler manifolds. This is a joint work with Qingchun Ji.

NCS MAA Fall 2018 Meeting: October 12-13, 2018 at Southwest Minnesota State University

MathFest 2018: August 1-4, 2018 at Denver, Co